The Geography of Obesity: Mapping and Modeling in King County

Third King County Overweight Prevention Initiative Forum: *Activate*
Friday, October 14, 2005

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ECOR

UW Exploratory Center for Obesity Research

New Teams.
Real Solutions

Acknowledgements

- Apart from mine, much of this material is drawn from the work of:
  - Luc deMontigny (PhD student, UW-CAUP)
  - Lin Lin (PhD student, UW-CAUP)
  - Anne Vernez Moudon (Professor, UW-CAUP, director of the Urban Form Lab)

The Big Picture

- Use of geospatial analysis tools can increase our ability to understand spatially-related factors contributing to the obesity epidemic.

Outline

- Background: GIS, Epidemiology, the Built Environment, Spatial Scale & Unit of Analysis
- Current Research from the Urban Form Lab
  - Walkable-Bikeable Communities Analyst (ArcView GIS Extension for Quantifying the Built Environment)
  - Fast Food Location Analysis
  - GIS-Based Spatial Sampling for SES, Behavior, and the Built Environment
  - Surface Modeling/Interpolation of Walkability Indices

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Background: What is GIS?

- A computer-based method for
  - Capture,
  - Storage,
  - Manipulation,
  - Analysis, and
  - Display

    of spatially referenced data

Background: What is GIS?

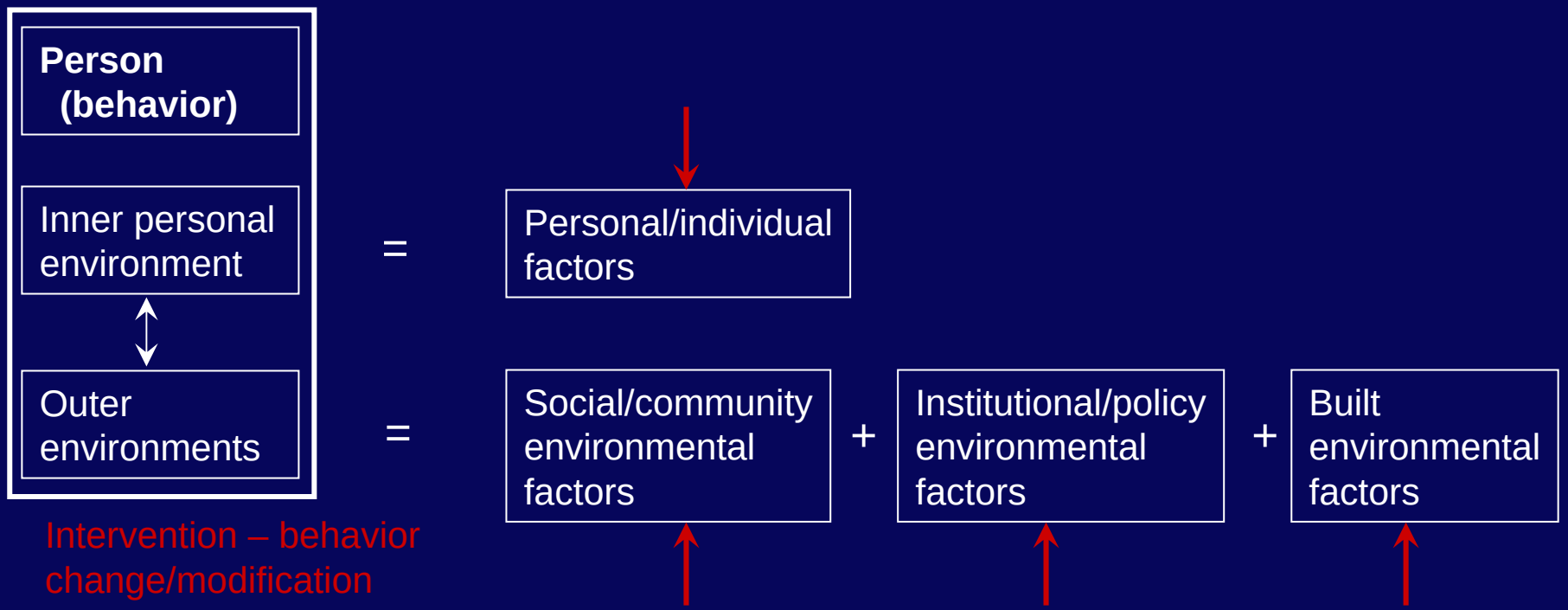
- Any object or phenomenon that is or can be placed on a map can be stored, managed, and analyzed in a GIS.
  - Built environment features (streets, buildings, bus routes, restaurants, schools)
  - Households (address points, tax-lot polygons)
  - Individuals (points or travel lines/polygons)
  - Ground surface elevation or slope
  - Movement of objects through time and/or space

Background: Why is GIS Important in Epidemiology?

- Epidemiology and public health are interested in population-wide effects
- Population-wide effects can only be ascertained from individual-level measurements
- GIS allows the measurement of ***individual characteristics*** within an explicitly spatial context
- If location is an important factor in a public health issue, GIS should be incorporated as a data management and analysis tool

Background: Conceptual Framework for Social Ecologic Model

- Social ecologic model considers impacts of environment (institutional, physical, social, etc.) on behavior. (Stokols, 1992; Sallis and Owen 1997)



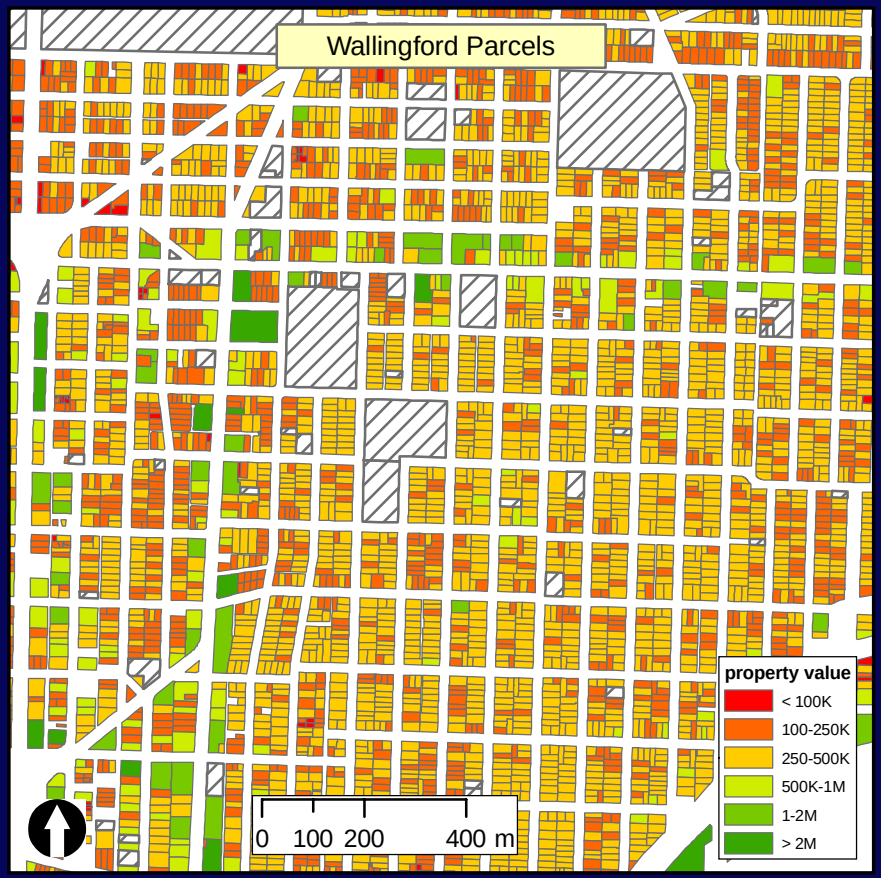
Background: The Built Environment Matters

- Associations between income and built environment
- Associations between walking/transit use and built environment
- Confounder in studies of behavior and the built environment: Self-selection and causation
  - Do people move to walkable neighborhoods and then start walking, or do walkers search out walkable neighborhoods?
  - “We shape our buildings; thereafter they shape us.”
    -Sir Winston Churchill

The Big Picture

- We can intervene in these arenas:
  - Social/Community
  - Institutional/Policy
  - Built Environment

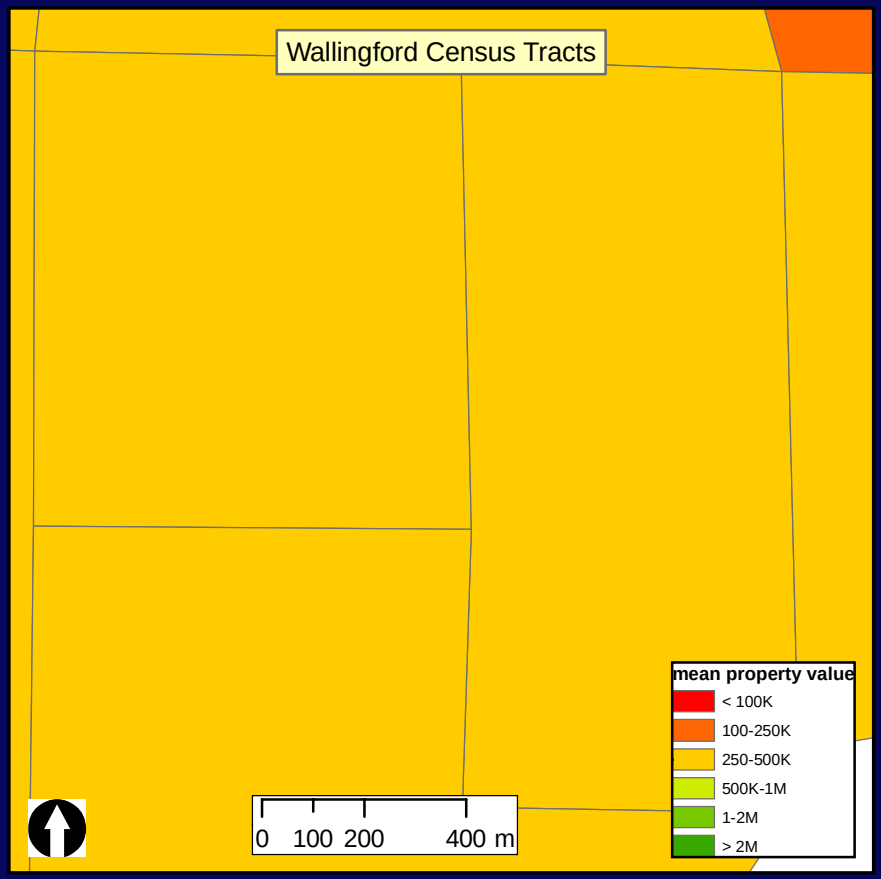
Background: Comparing Units of Spatial Data Capture, Storage, and Analysis (Tax-lots)



- Tax-lot-level data are detailed and varied
- Variation at the household-unit population level is maintained and can be used for analytical purposes

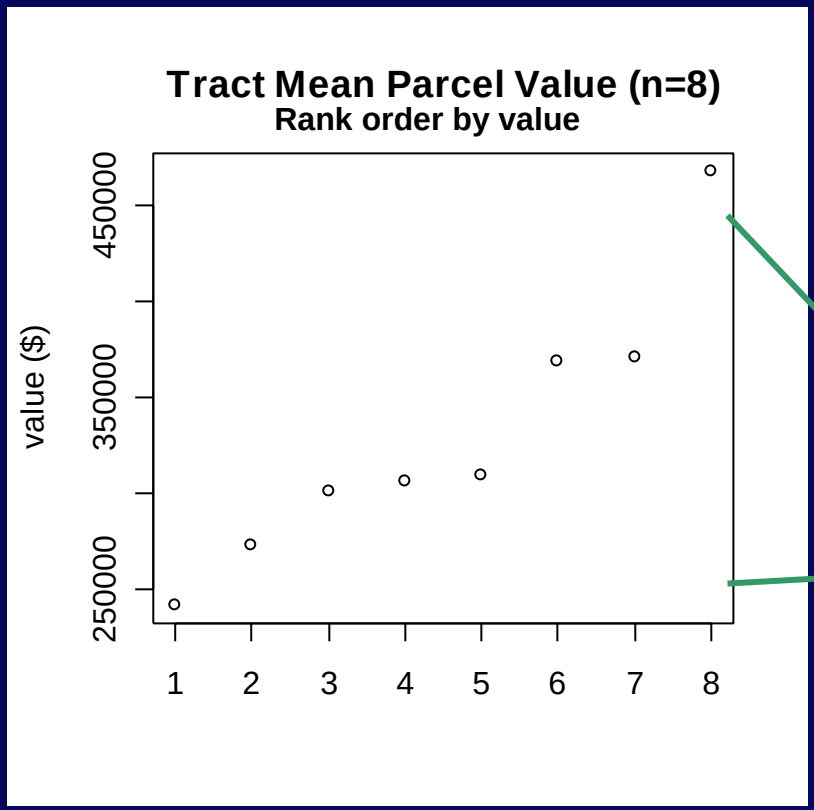
Background: Comparing Units of Spatial Data Capture, Storage, and Analysis (Tax-lots)

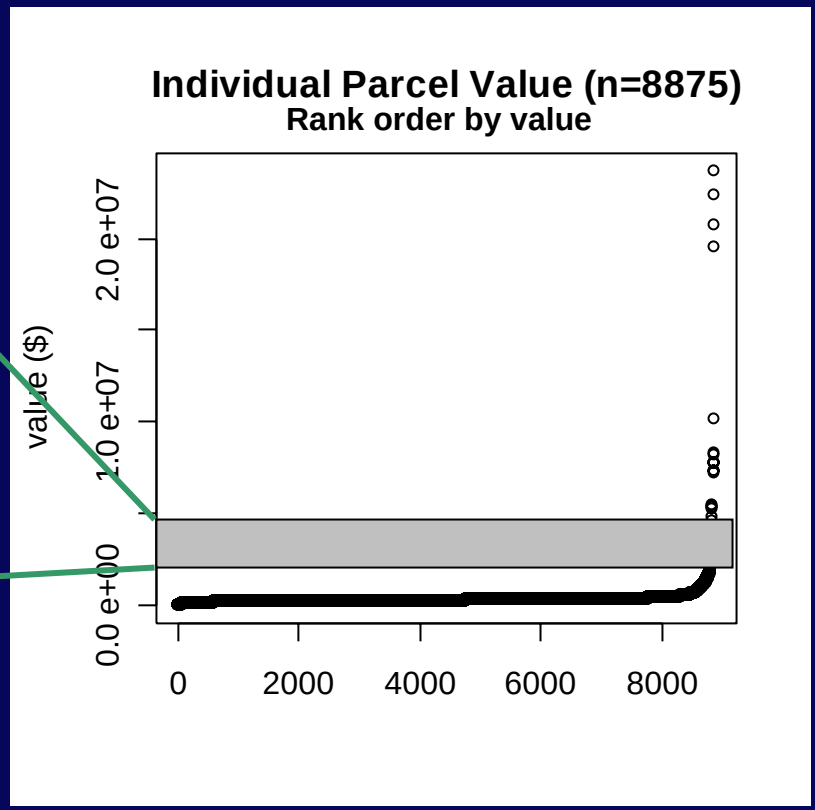
Background: Comparing Units of Spatial Data Capture, Storage, and Analysis (Census Tracts)



- Census data lack detail and variation
- Within-tract variation is lost as geometries become larger and more aggregated

Background: Unit of Data Capture & Analysis: Affects Quantitative Output





The Big Picture

- Epidemiologic data model:

  To understand what is happening to individuals or households, we need data with resolution at the individual or household level.

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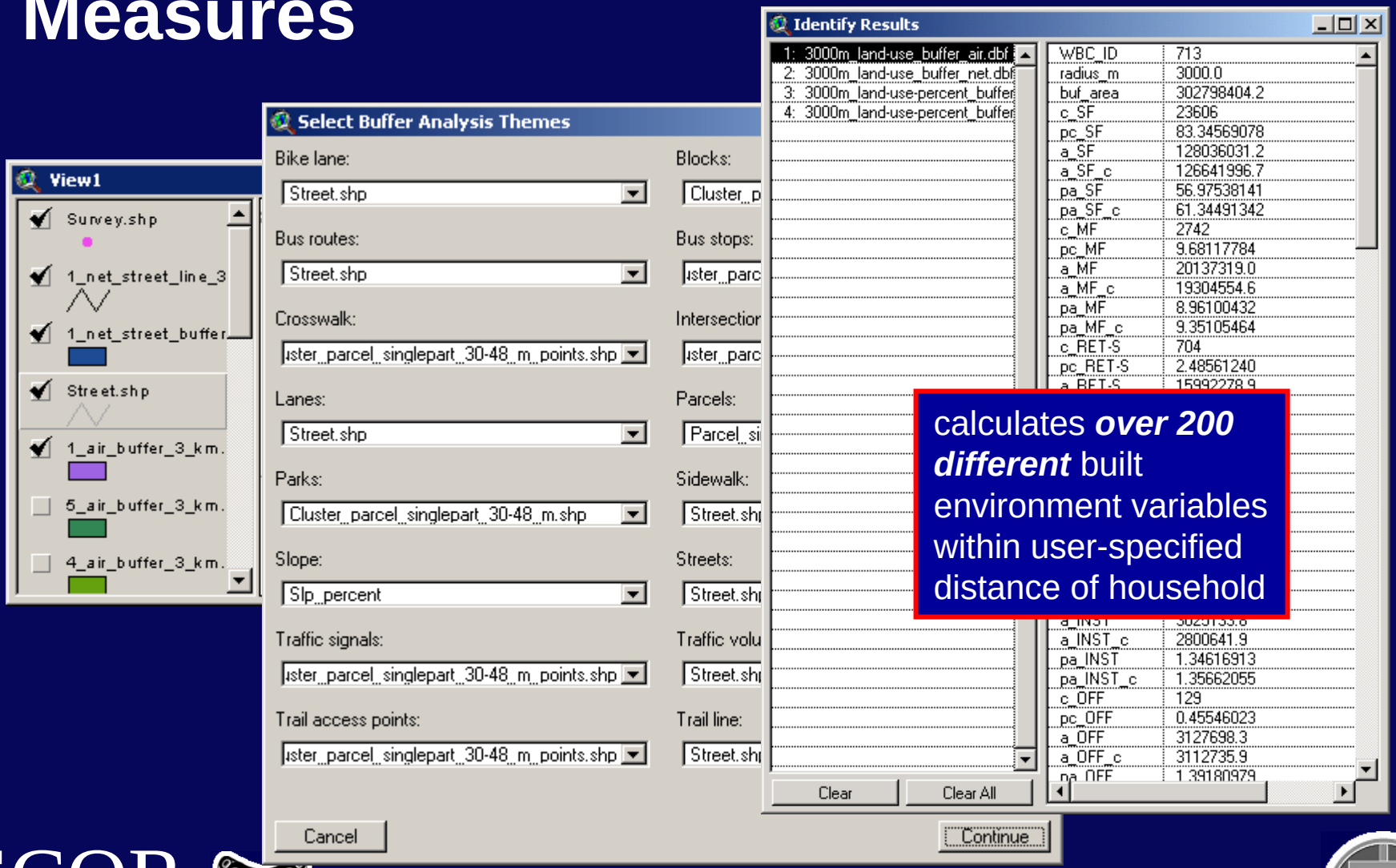
The WBC Analyst ArcView GIS Extension

- Automates several measurement methods (inventories “what” and “where” of the built environment)
  - What features are within walking distance to the household?
    - Land use proportions
    - Count/length/area of features, e.g., groceries, restaurants, bus stops, streets, sidewalks
  - How close (distance) are various features?
    - Grocery stores, restaurants, schools, etc.

WBC Analyst: Proximity and Buffer Measures



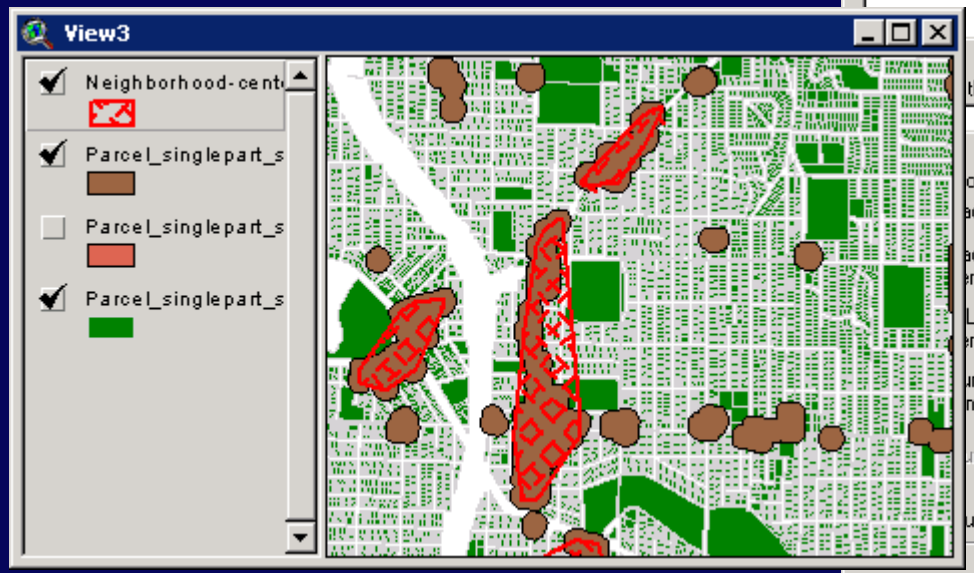
calculates ***over 200 different*** built environment variables within user-specified distance of household

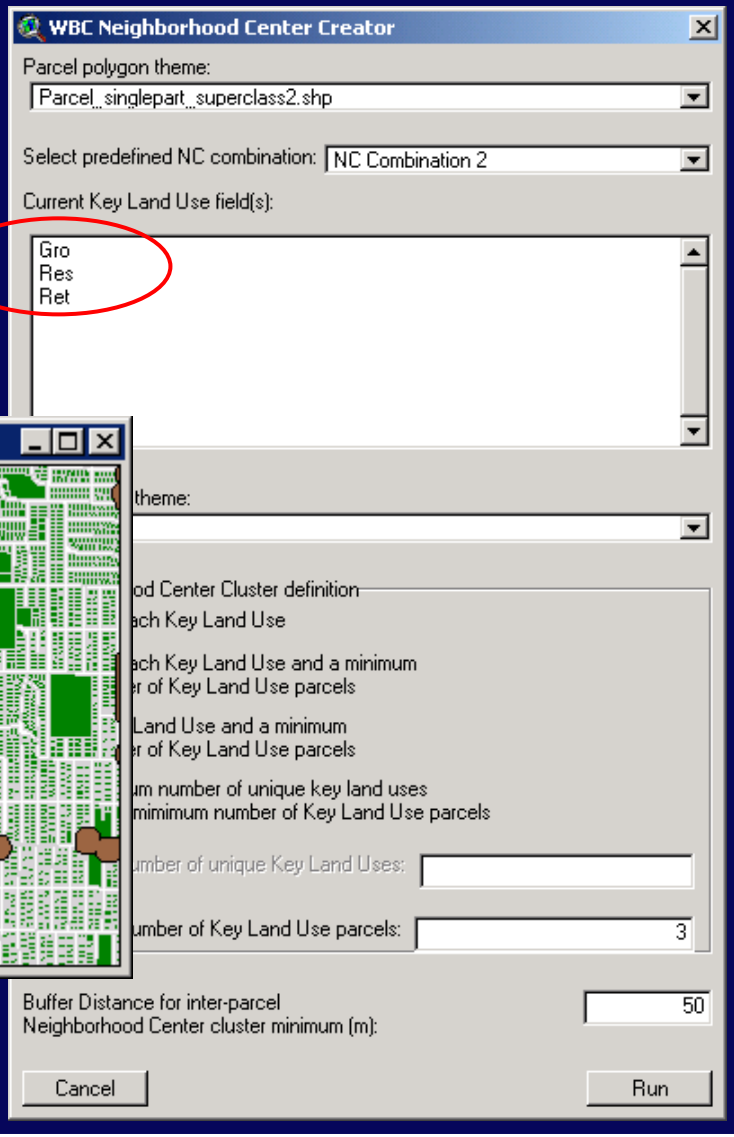
WBC Analyst: "What" and "Where" Can Explain the Choice to Walk

- Output of GIS coupled with telephone survey data
- Using multinomial logit we were able to explain 35% of the variation in walking with only socio-demographic variables:
  - age
  - education
  - neighborhood social environment
  - attitude toward traffic and environmental quality
- Adding environmental variables (presence of certain land uses within 1 mile of the home) obtained from the GIS ***increased the R^2 to 47%***
- Extension is currently being used by researchers in public health, epidemiology, and transportation

WBC Analyst: Neighborhood Centers (NCs)

- Generates “clusters” from locally aggregated land use tax-lots





The Big Picture

- Using GIS we can measure and model factors of the built environment that are contributors to obesity.

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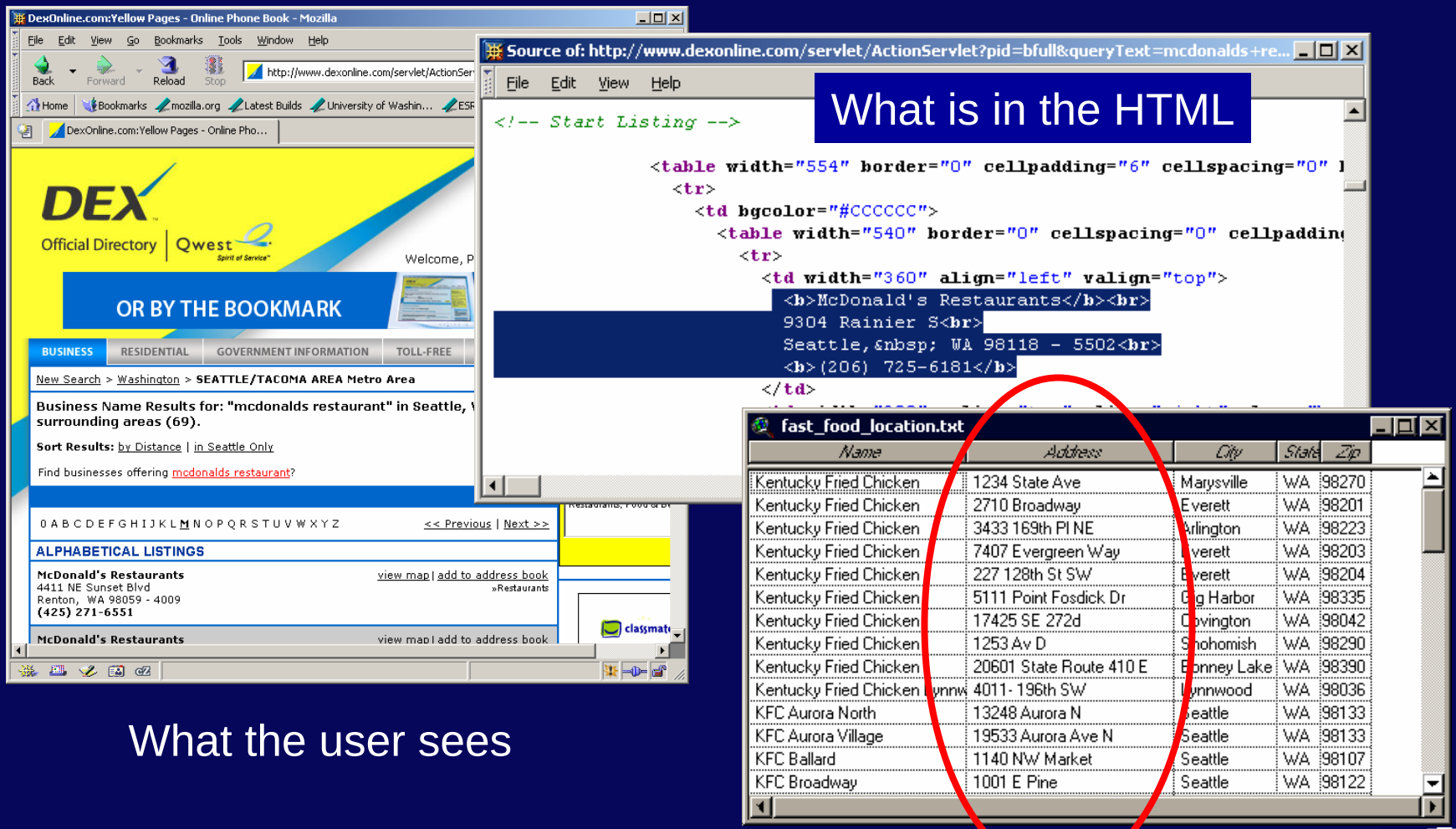
Example Application: Fast Food Location Analysis

- Analysis of location of fast food restaurants
- How do the densities and counts of these restaurants vary through space?
- Are the differences in densities related to demographic variables?

Fast Food Location Analysis: Where Are They?

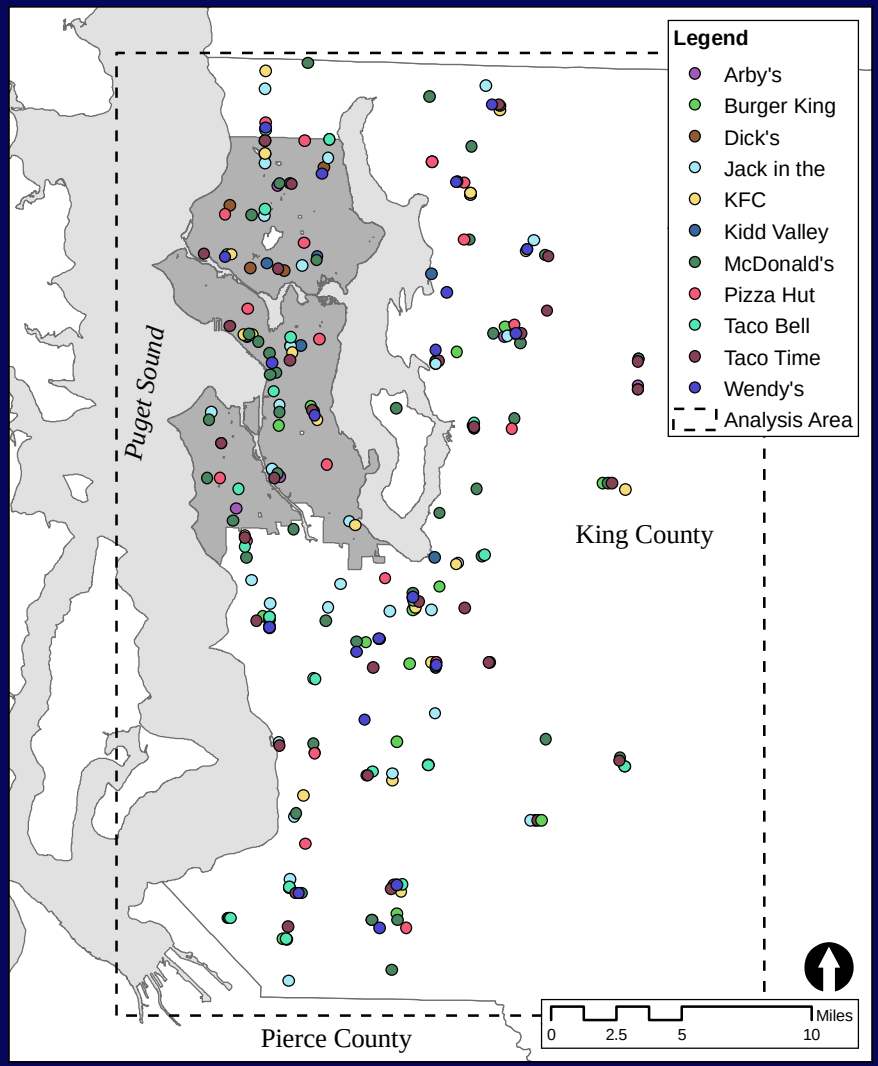
- Fast food restaurant addresses are available free online (Qwest – dexonline.com)
- Online telephone directories have regular structure (server-side script generated html) that can be extracted with customized client-side scripts

Fast Food Location Analysis



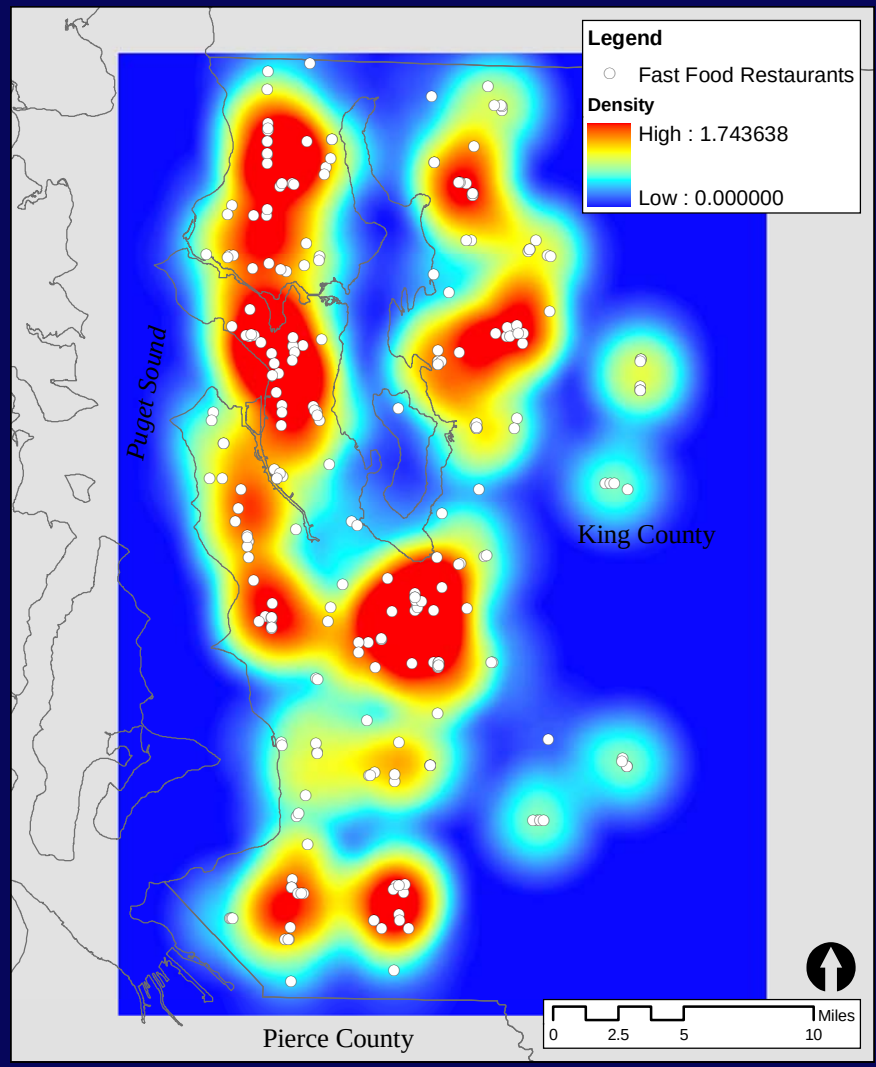
Fast Food Location Analysis

- *Asset mapping*: address geocoding places fast food restaurants in spatial framework common with other regional data sets



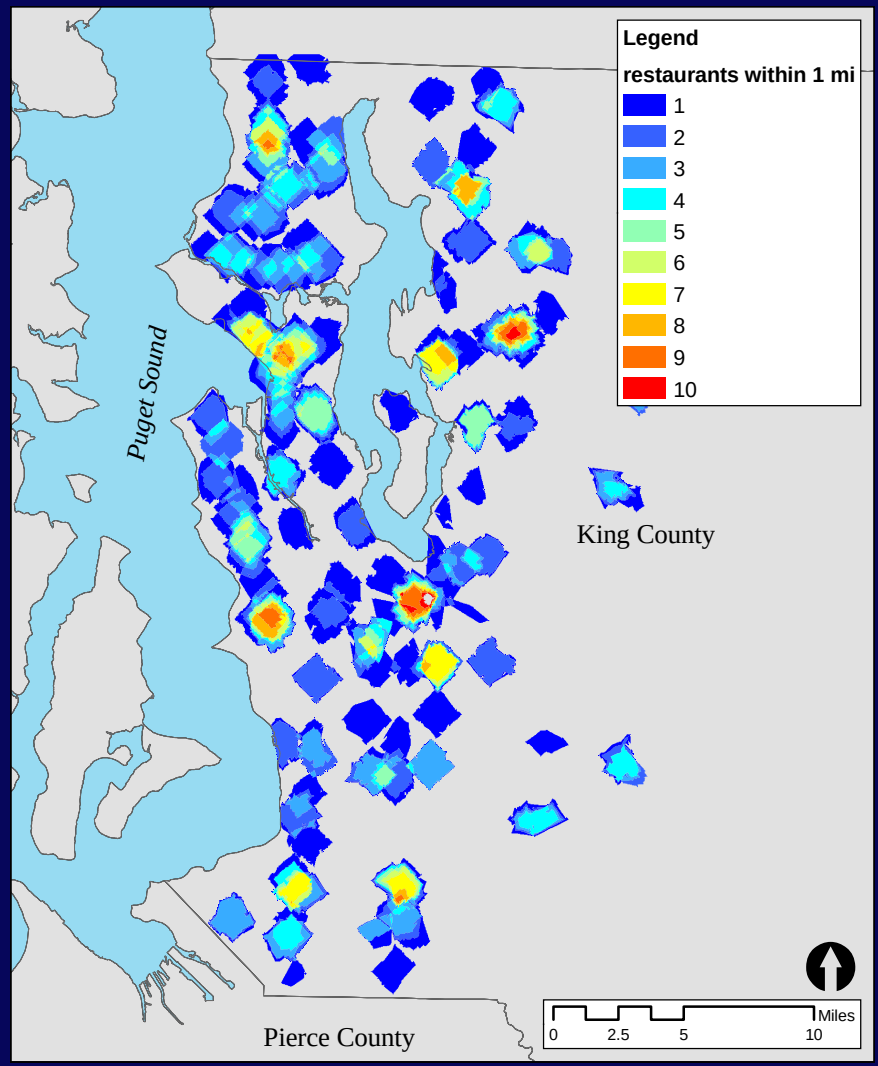
Fast Food Location Analysis

- Analysis of locations
  - Kernel interpolation method
  - Calculates density of fast food restaurants at all locations across study area



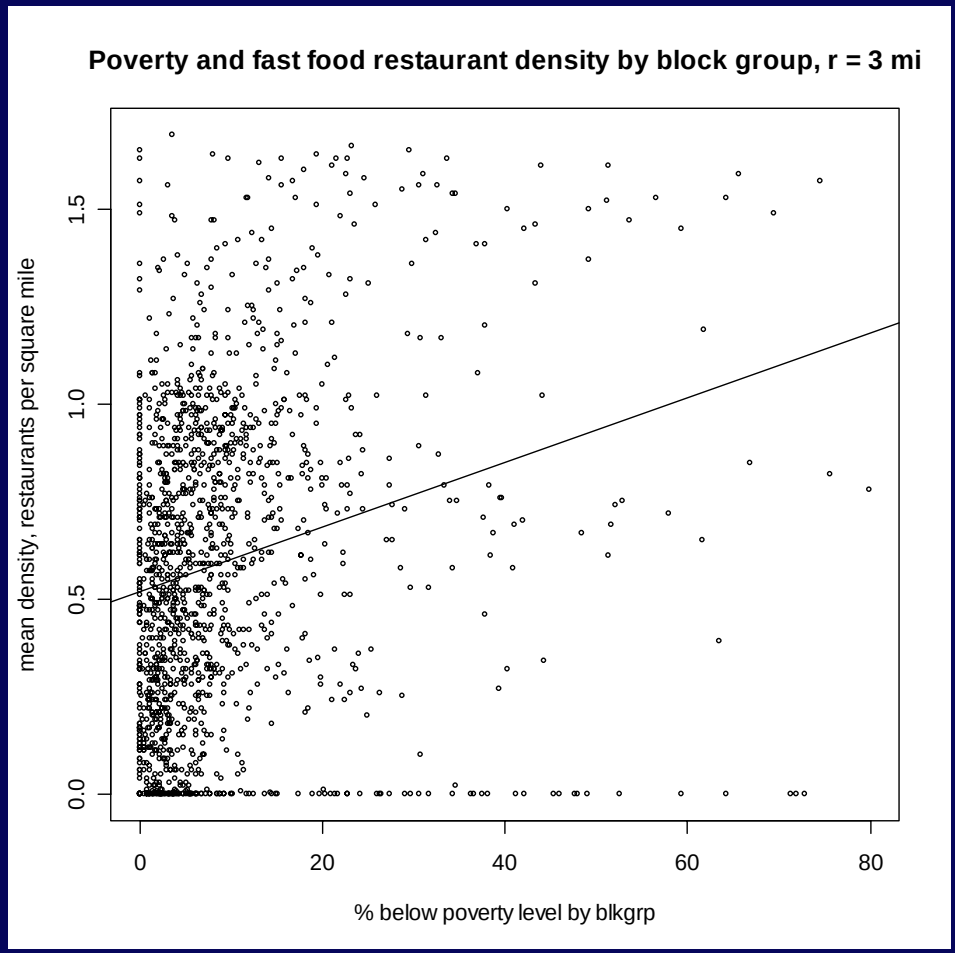
Fast Food Location Analysis

- Analysis of locations
  - Count of number of fast food restaurants within 1 mile for all locations



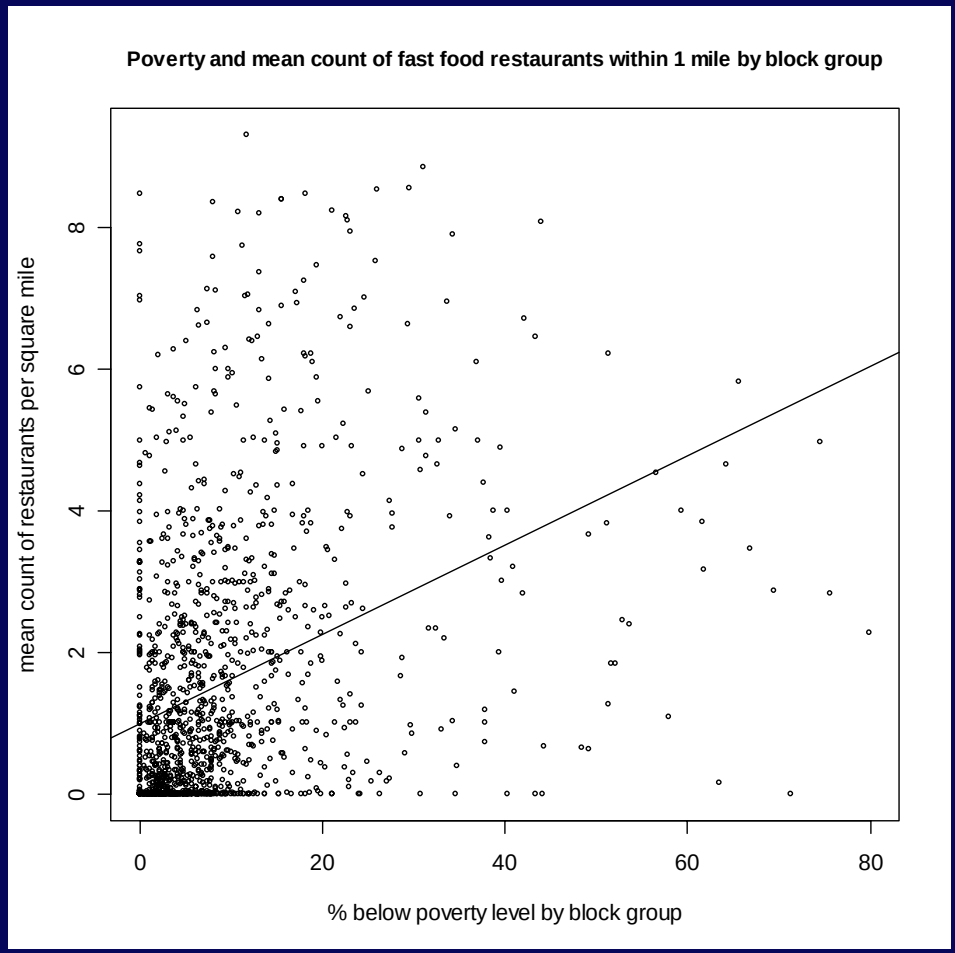
Fast Food Location Analysis

- Sociodemographic pattern?
- Density of fast food restaurants appears higher in block groups with higher poverty levels
- Pearson's Product Moment correlation $\rho = 0.23$, $p < 0.005$



Fast Food Location Analysis

- Sociodemographic pattern?
- Mean count of fast food restaurants higher in block groups with higher poverty levels
- Pearson's Product Moment correlation $\rho = 0.25$, $p < 0.005$



The Big Picture

- Fast food restaurants in western King County are located in higher densities within lower income census block groups.

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GIS-Based Spatial Sampling for SES, Behavior, and the Built Environment

Spatially-based population sampling is of benefit to inferential research using surveys. Our approach:

1. Ensures sufficient variation in and proper distribution of key variables in the sample
   (e.g., environmental characteristics such as residential density, proximity to activities, schools)
2. Ensures adequate occurrences of rare events in the sample
   (e.g., respondents belonging to racial minorities, those living close to public transit)
3. Controls for conditions of no interest
   (e.g., areas of low residential density)

Novel approach: Spatial sampling with GIS Method

1. Use the GIS to spatially stratify population of interest to construct a sample frame. Data can be taken from any GIS database, such as:
   - Tax-lot data: e.g., land use, assessed property values
   - Political data: e.g., urban growth boundary
   - Environmental data: e.g., slope
   - Census data: e.g., race

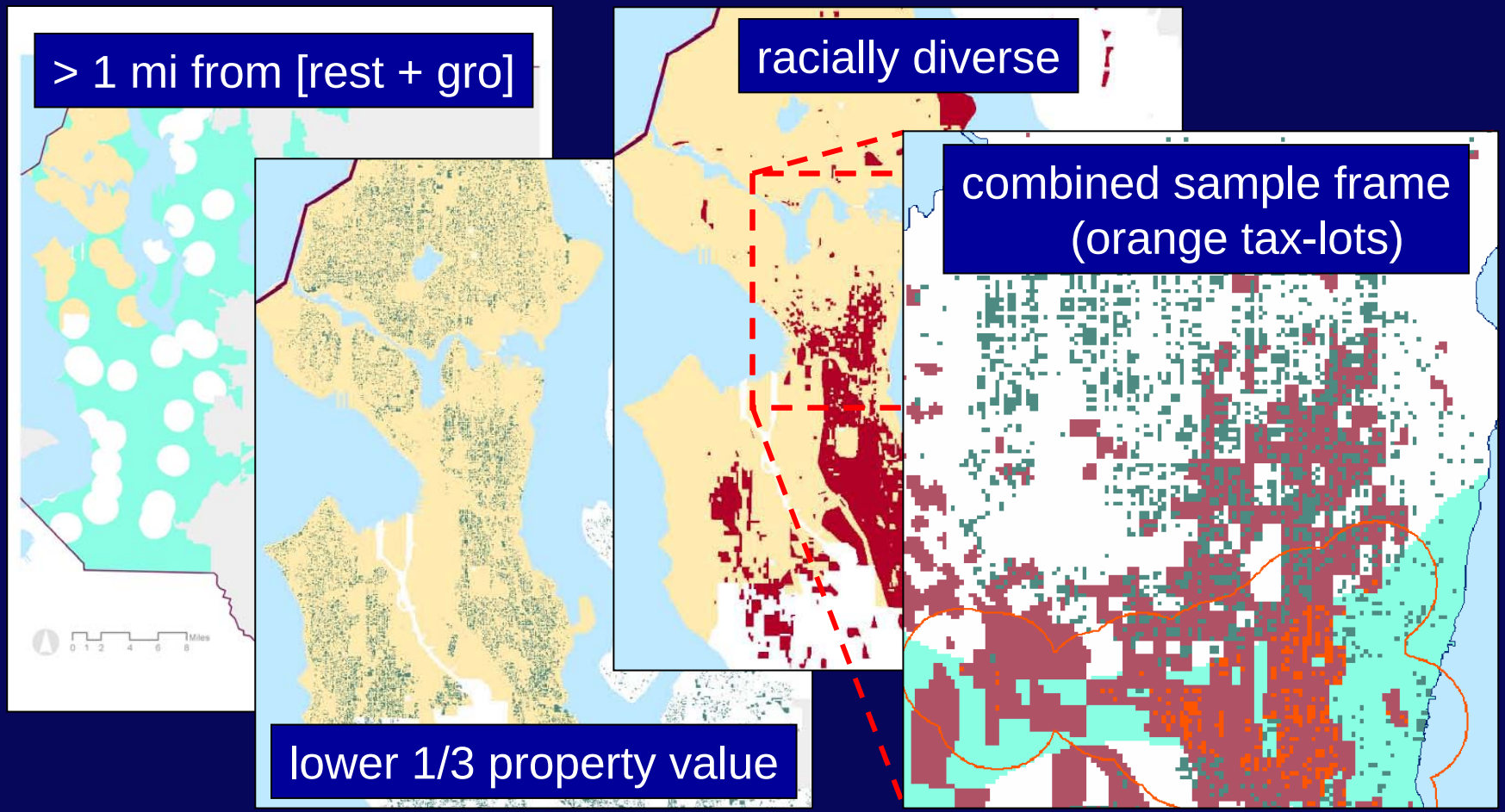
2. Randomly select individual residential units (a proxy for households) from the spatial sample frame. This limits the sample to a spatially and demographically specific population of interest.

GIS-Based Spatial Sampling: A Demonstration of the Approach

Example of criteria for delimiting a sample frame of a population “At Risk” of obesity: Households that reside:

- Farther than 1 mile from a Neighborhood Center cluster of grocery stores and restaurants
- In a residential unit in the bottom 1/3 of assessed property value
- In a census block with greater racial diversity
- Within the King County Urban Growth Boundary

GIS-Based Spatial Sampling: A Demonstration of the Approach



Spatial Sampling

- Used to generate the sample for households surveyed in the WBC project.
- Lee, C, Moudon, AV and Courbois, JP (in press). Built Environment and Behavior: Spatial Sampling Using Parcel Data, *The Annals of Epidemiology*

The Big Picture

- Using GIS in designing sampling strategies increases statistical power while limiting the study to a population of interest.

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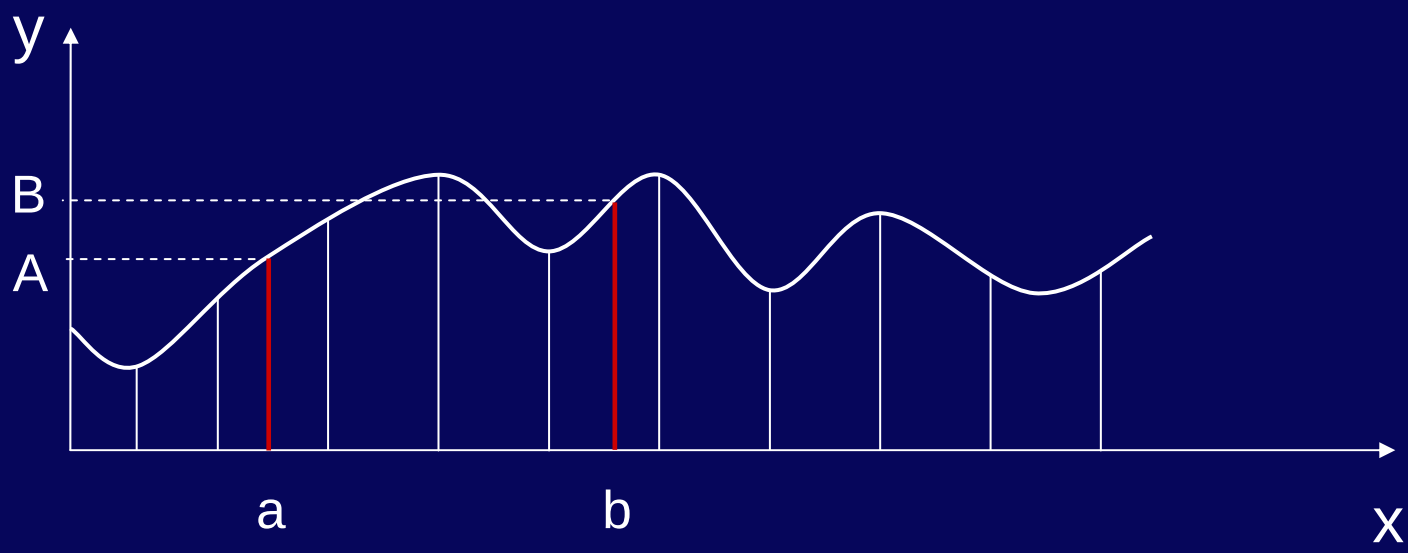
Surface Modeling Process



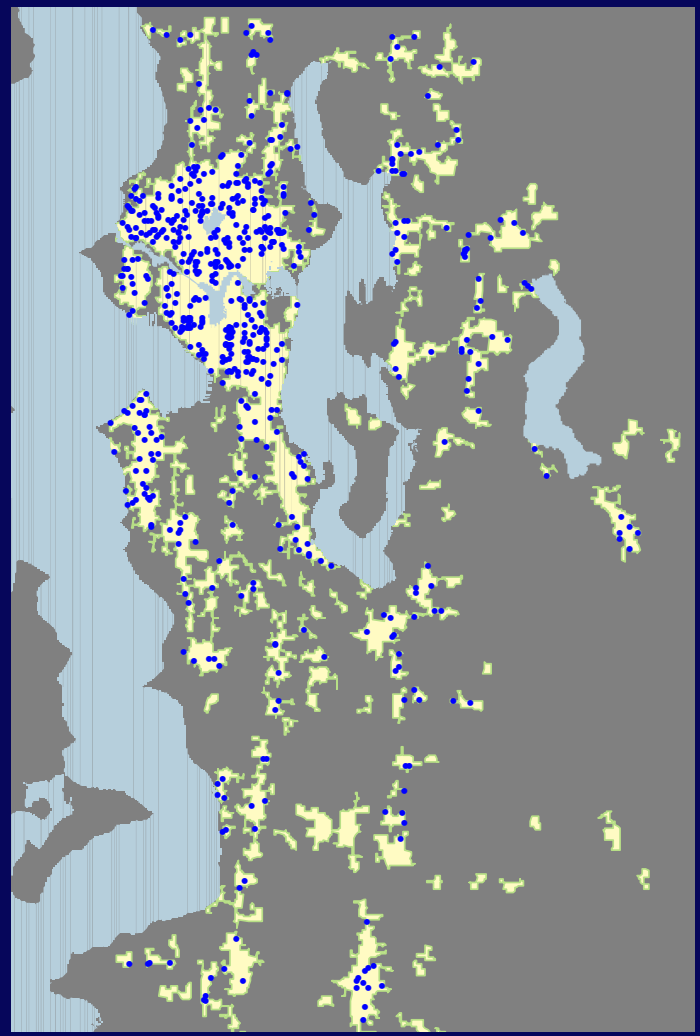
1. Measure sample locations
2. Create interpolated surface
3. Estimate values at non-sample locations

Application of Surface Modeling: Walkable-Bikeable Communities (WBC) Project

- Survey of 608 households (spatially sampled) for activity behavior & perception of environment (dependent variables)
- Measured built environment characteristics with WBC Analyst Extension in the GIS (independent variables)
- Multinomial logistic regression models developed to predict the probability of walking *moderately* (1-149 min/wk) or *sufficiently* (>= 150 min/wk) vs. not walking, based on built environment characteristics
- Surface modeling (Radial Basis Function) to interpolate walkability values at non-sampled locations

WBC Project Sample

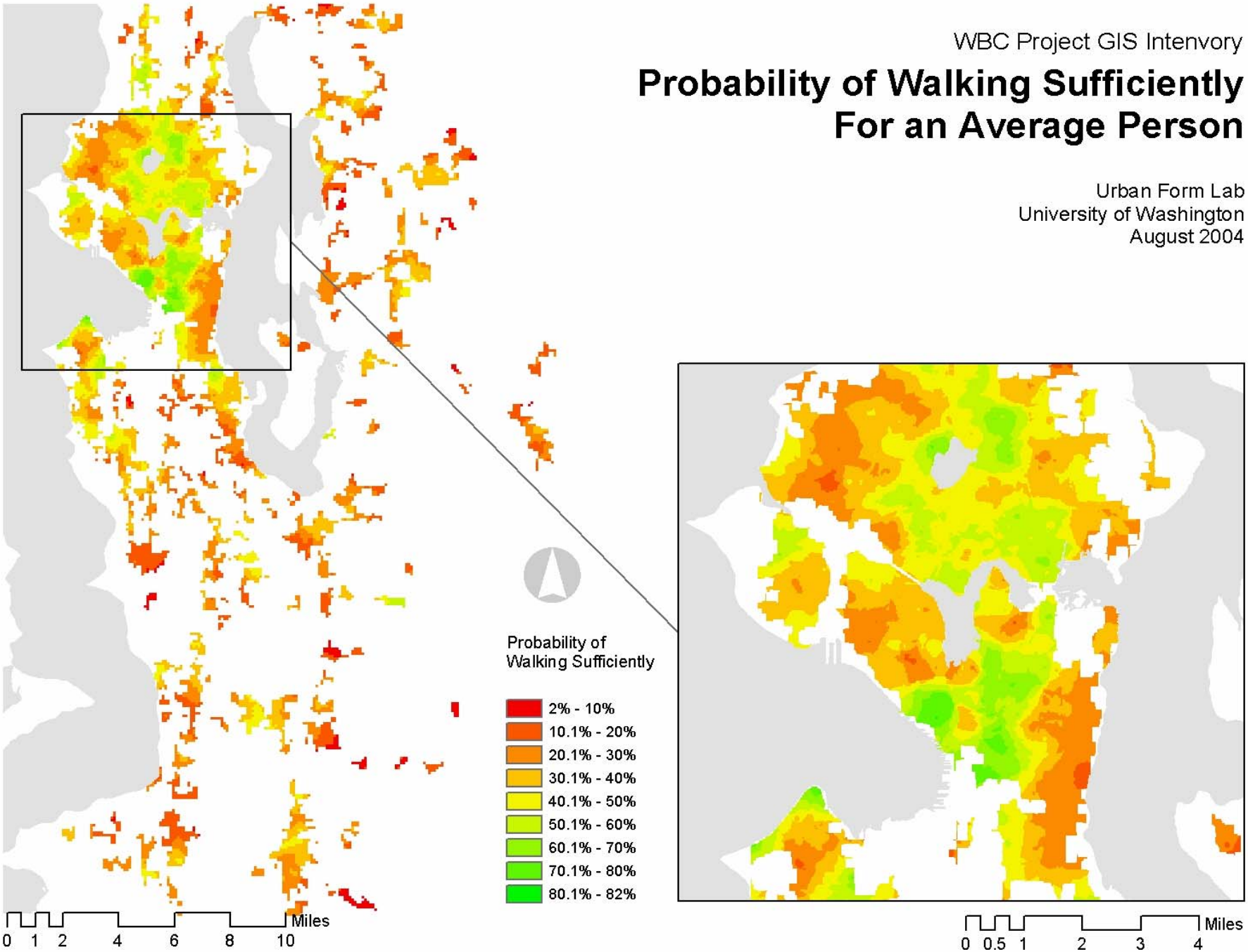
Household locations randomly sampled from the GIS-derived sample frame



WBC Project GIS Intenvory

Probability of Walking Sufficiently For an Average Person

Urban Form Lab
University of Washington
August 2004

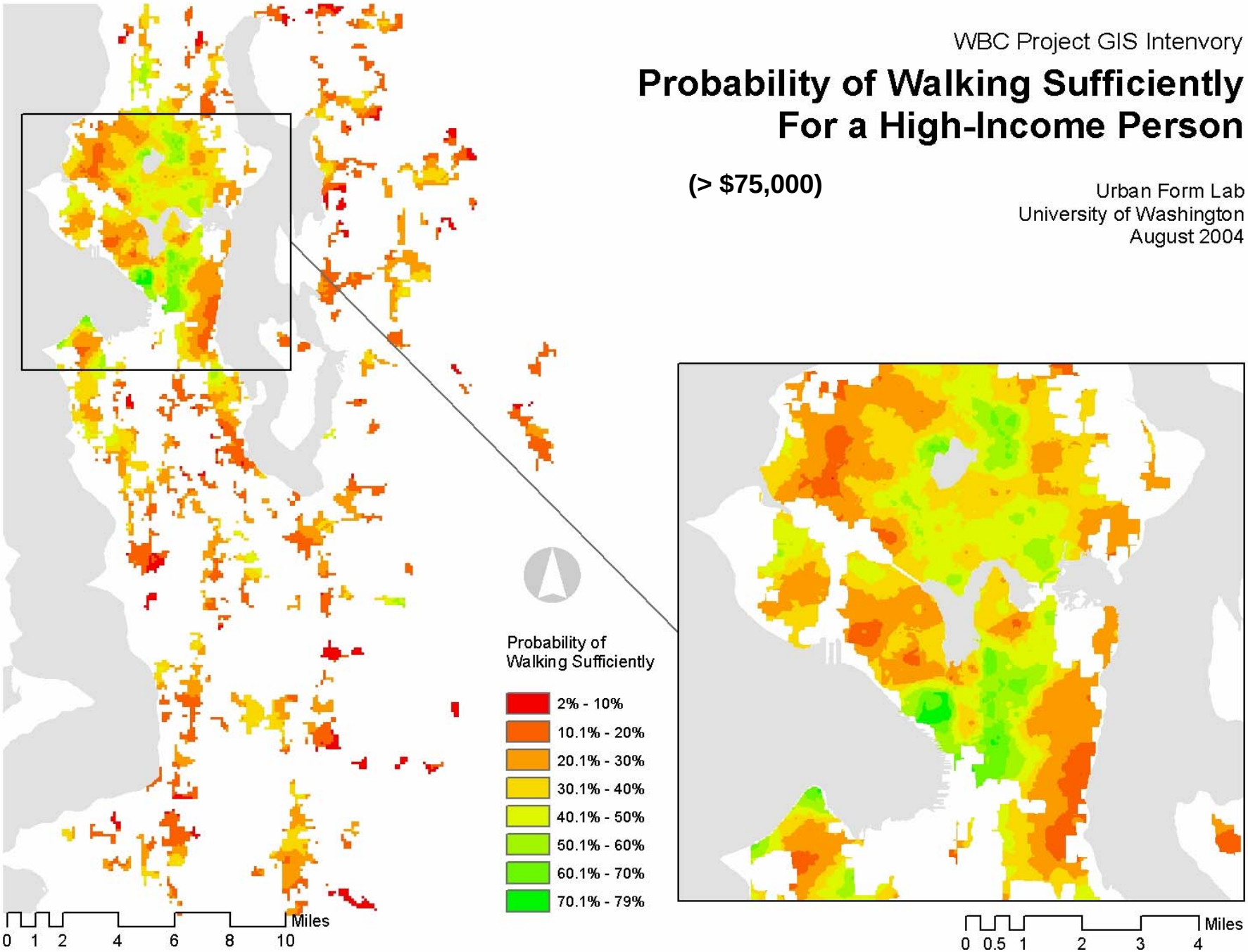


WBC Project GIS Intenvory

Probability of Walking Sufficiently For a High-Income Person

(> $75,000)

Urban Form Lab
University of Washington
August 2004

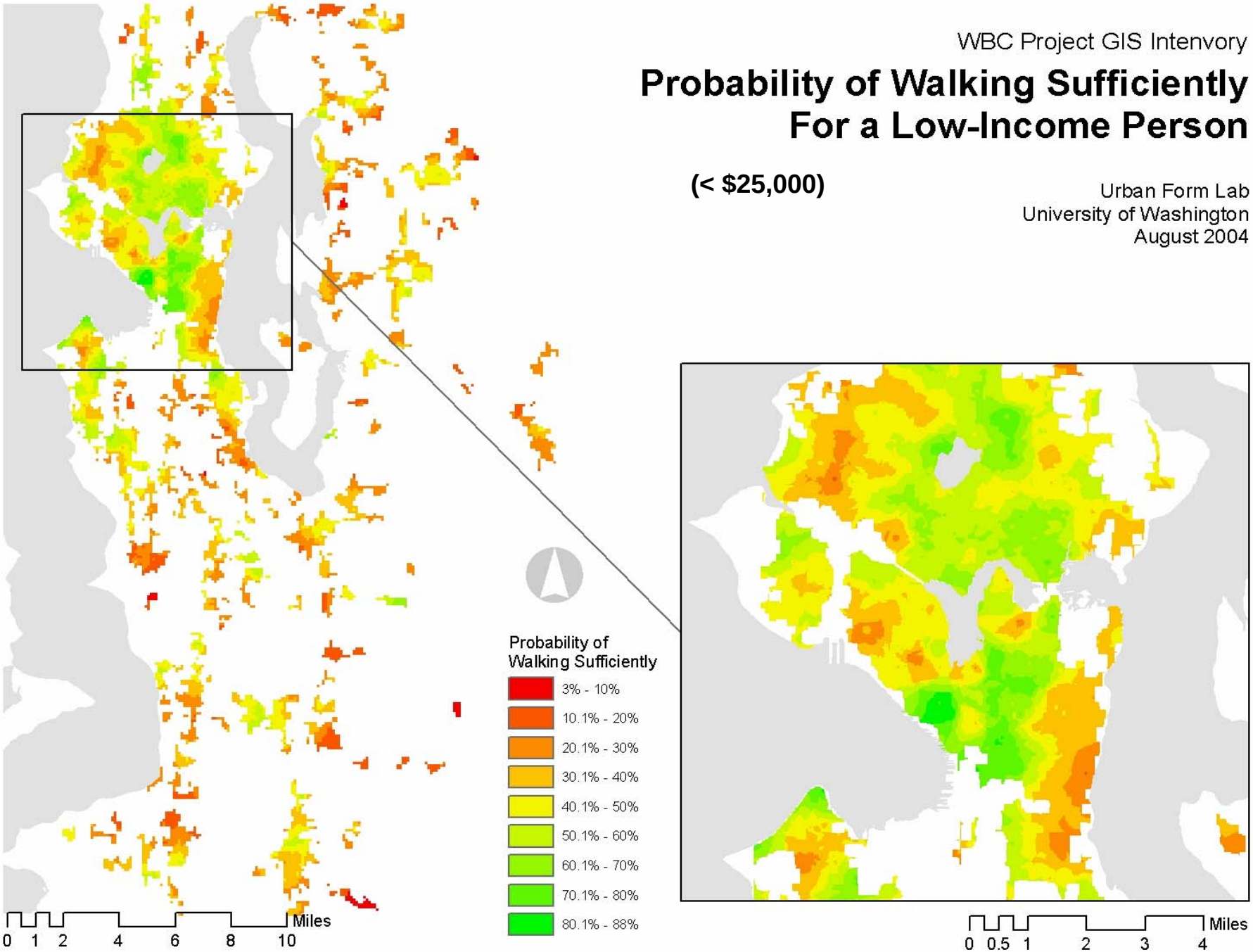


WBC Project GIS Intenvory

Probability of Walking Sufficiently For a Low-Income Person

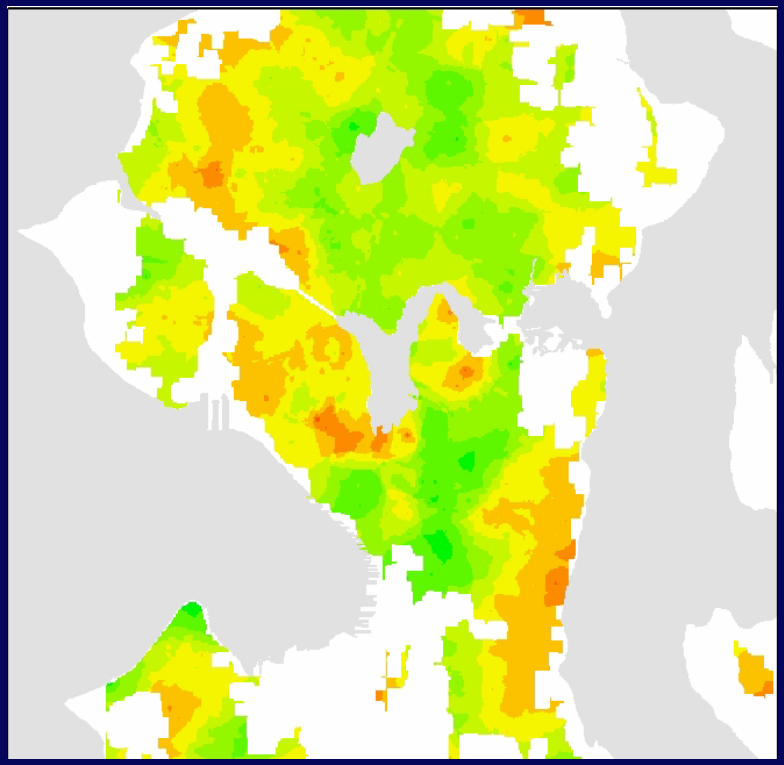
(< $25,000)

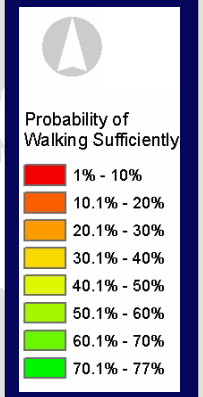
Urban Form Lab
University of Washington
August 2004



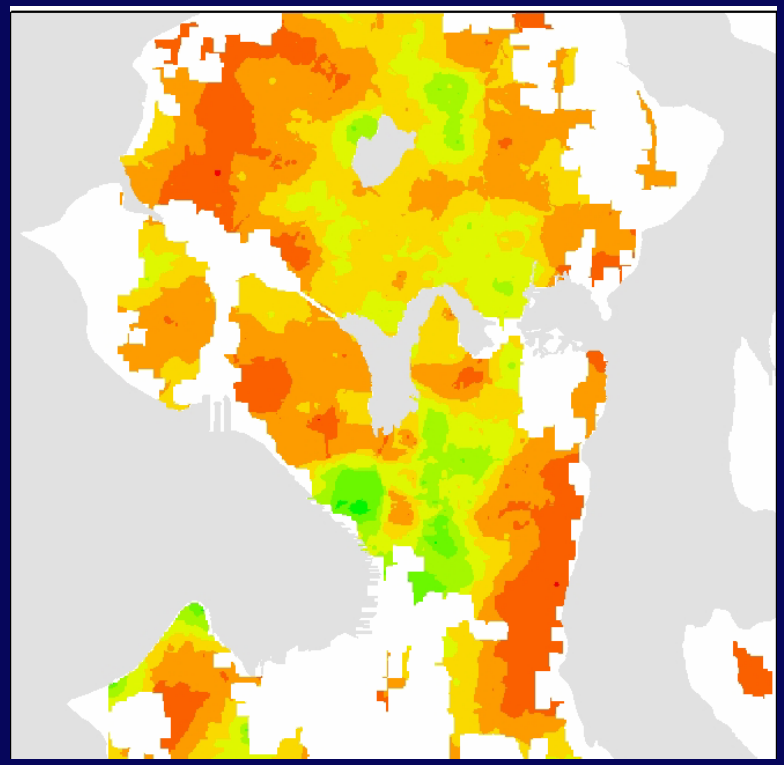
Likelihood of Sufficient Walking--Age

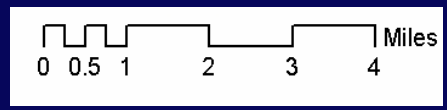
Older Adult (>65 y)





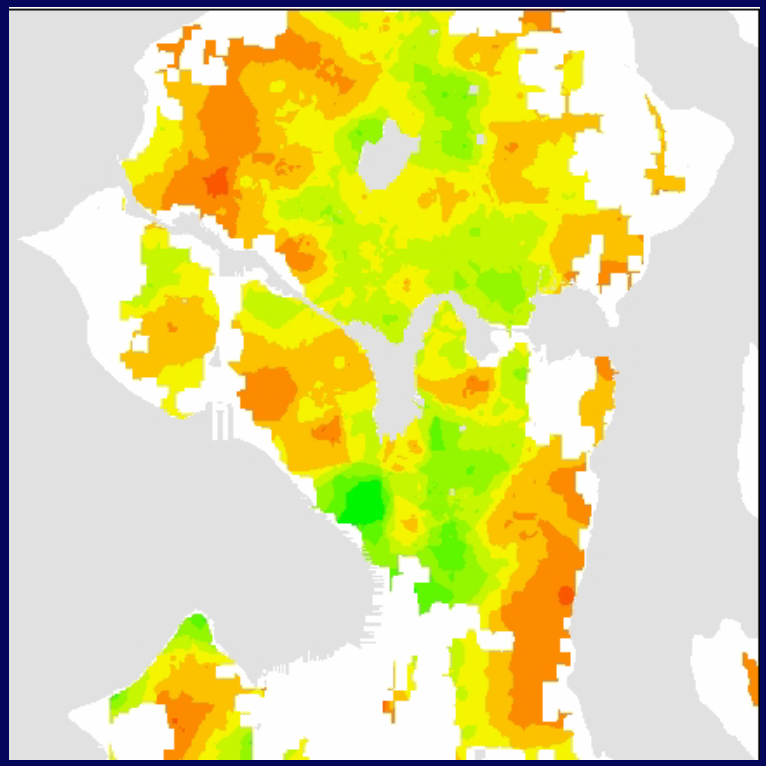
Younger Adult (<35 y)



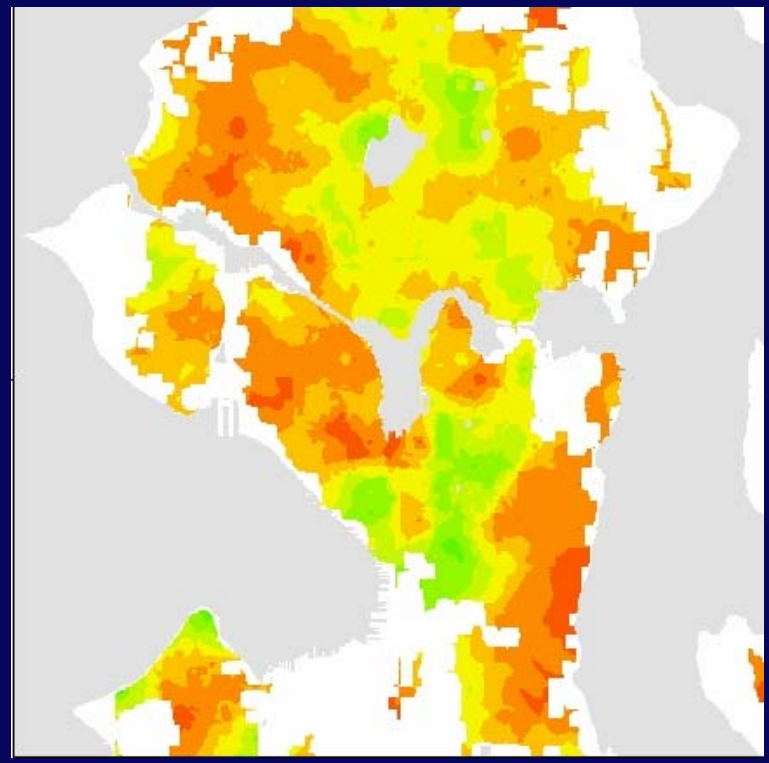


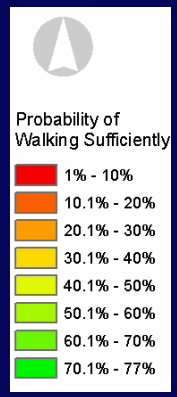
Likelihood of Sufficient Walking—Transit Usage

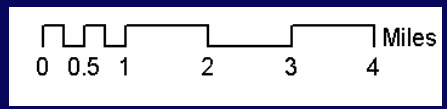
Transit User



Non-Transit User







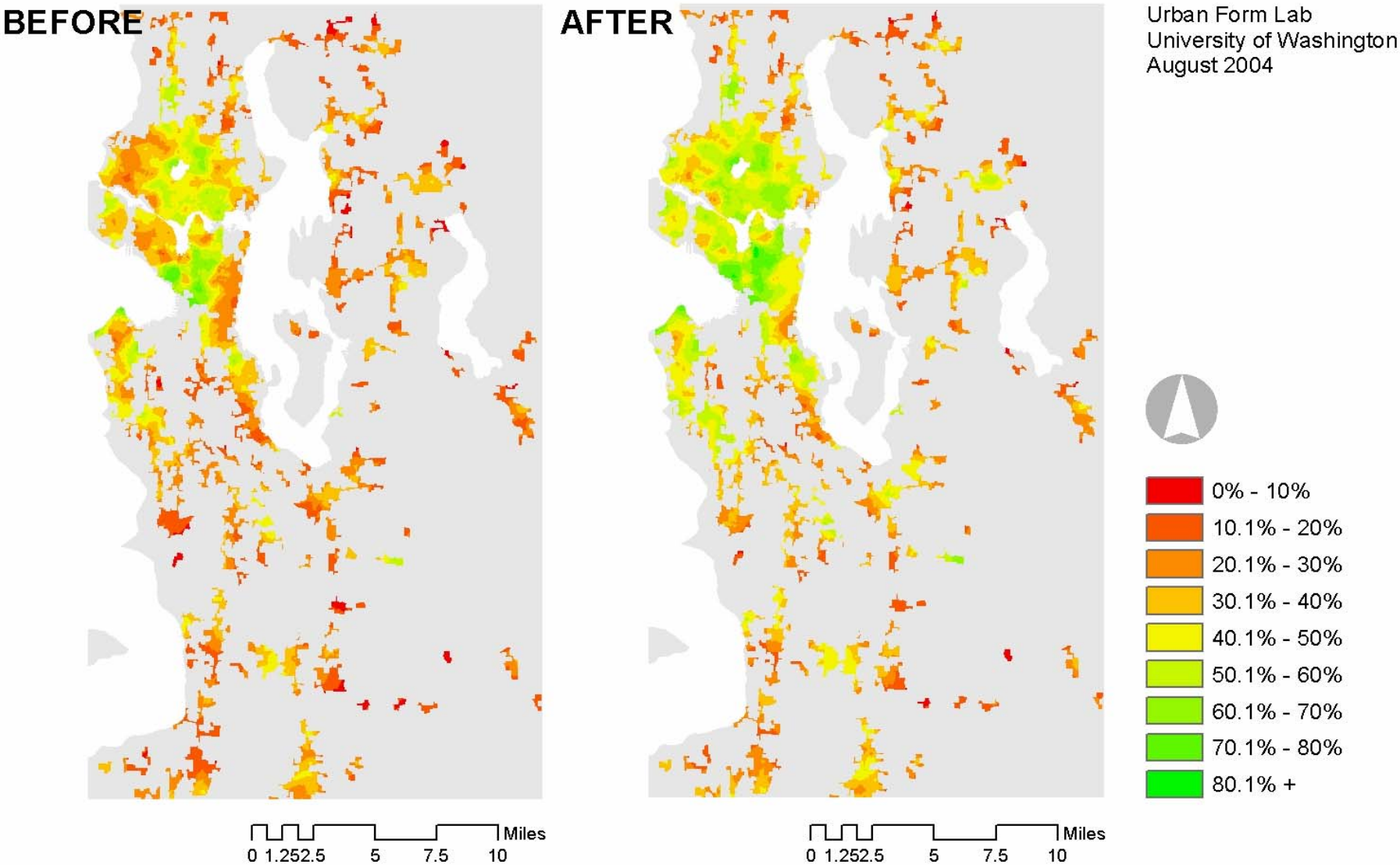
Environmental Intervention and Assessment Simulation

1. Change values of environmental variables in regression model to predict new walking probability under different scenarios
2. New surface interpolation generates “before” and “after” intervention surface models

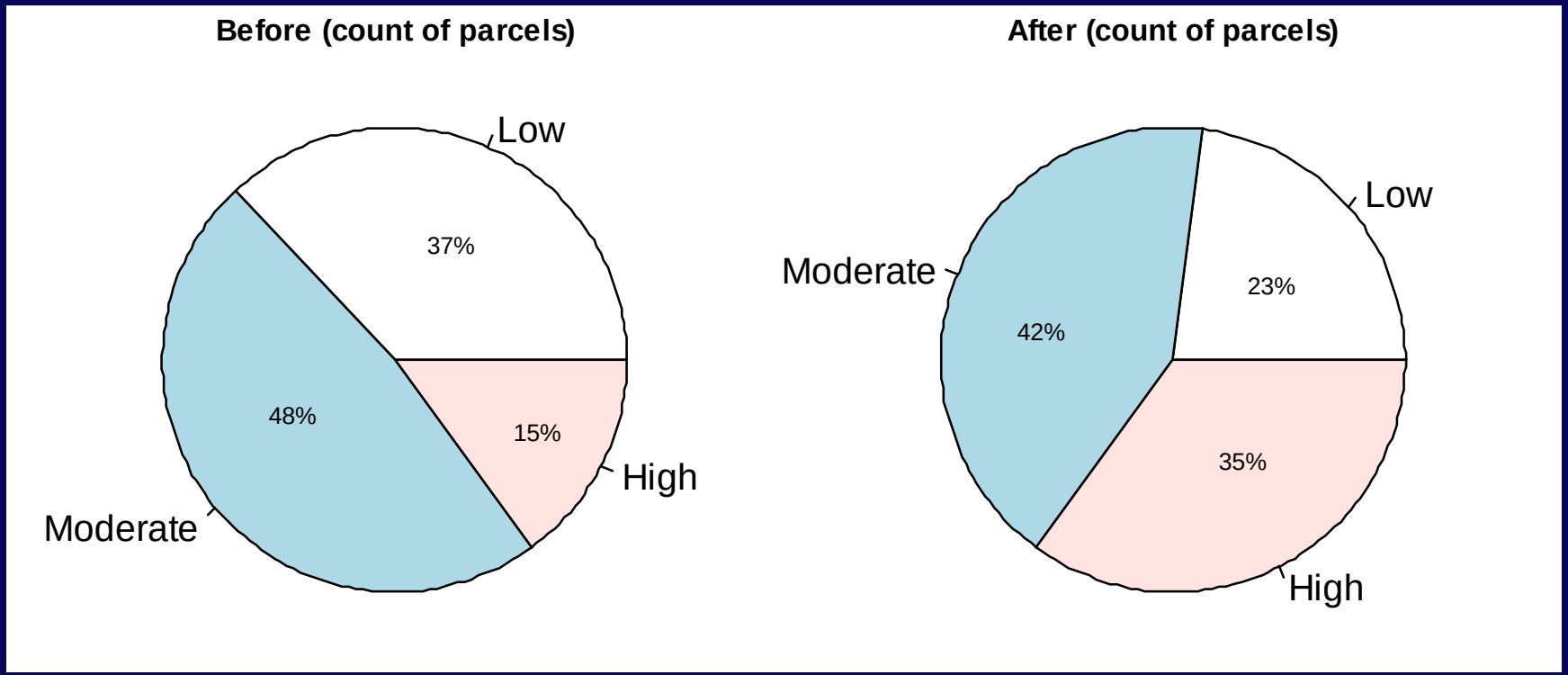
Allows an estimate of the impacts of environmental interventions

WBC Project GIS Intervention

Add 1 Grocery Store and 1 [Grocery+Restaurant+Retail] NC within 1 km of Home

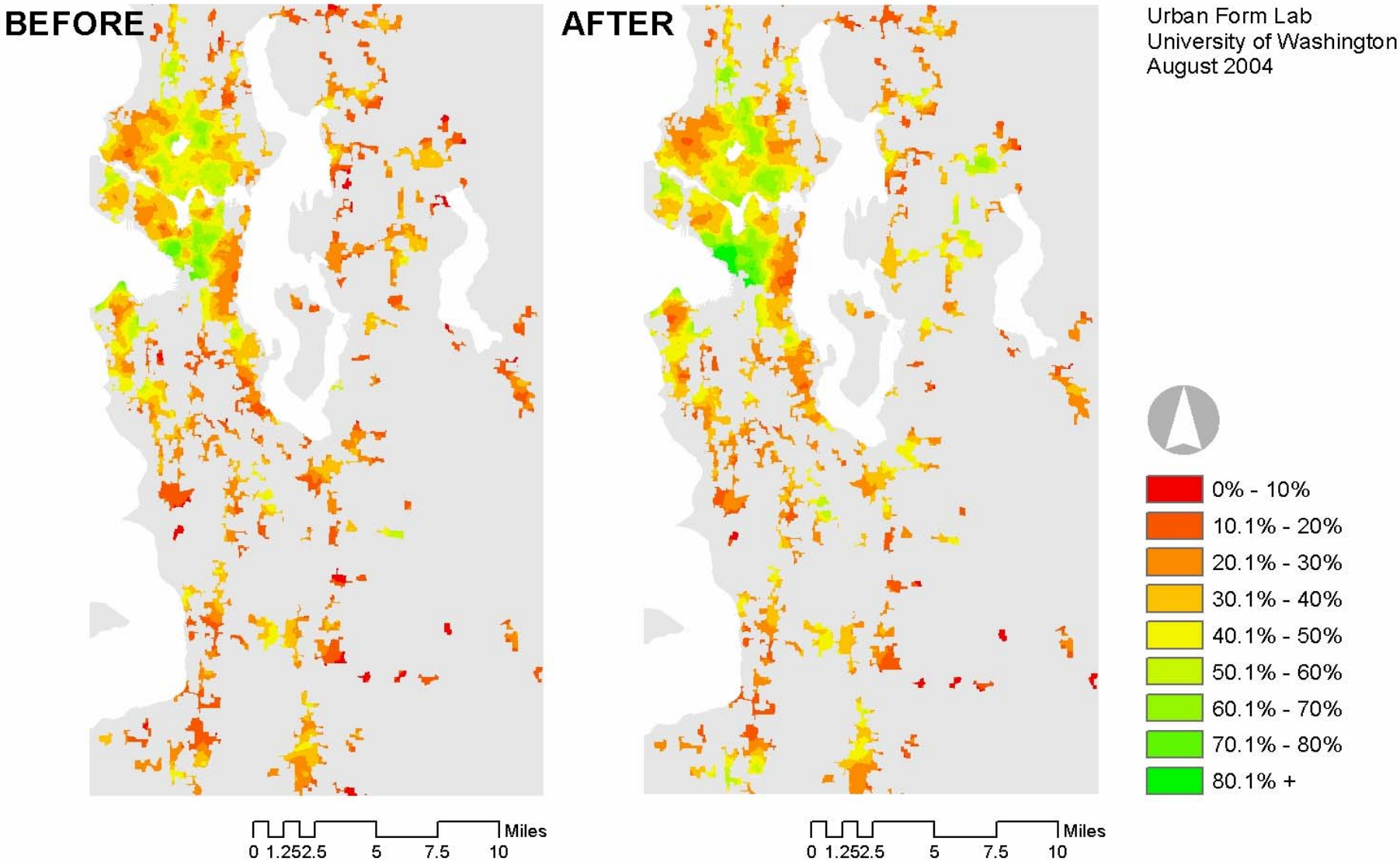


Add One Grocery and One Grocery+Restaurant+Retail NC within 1km of Home

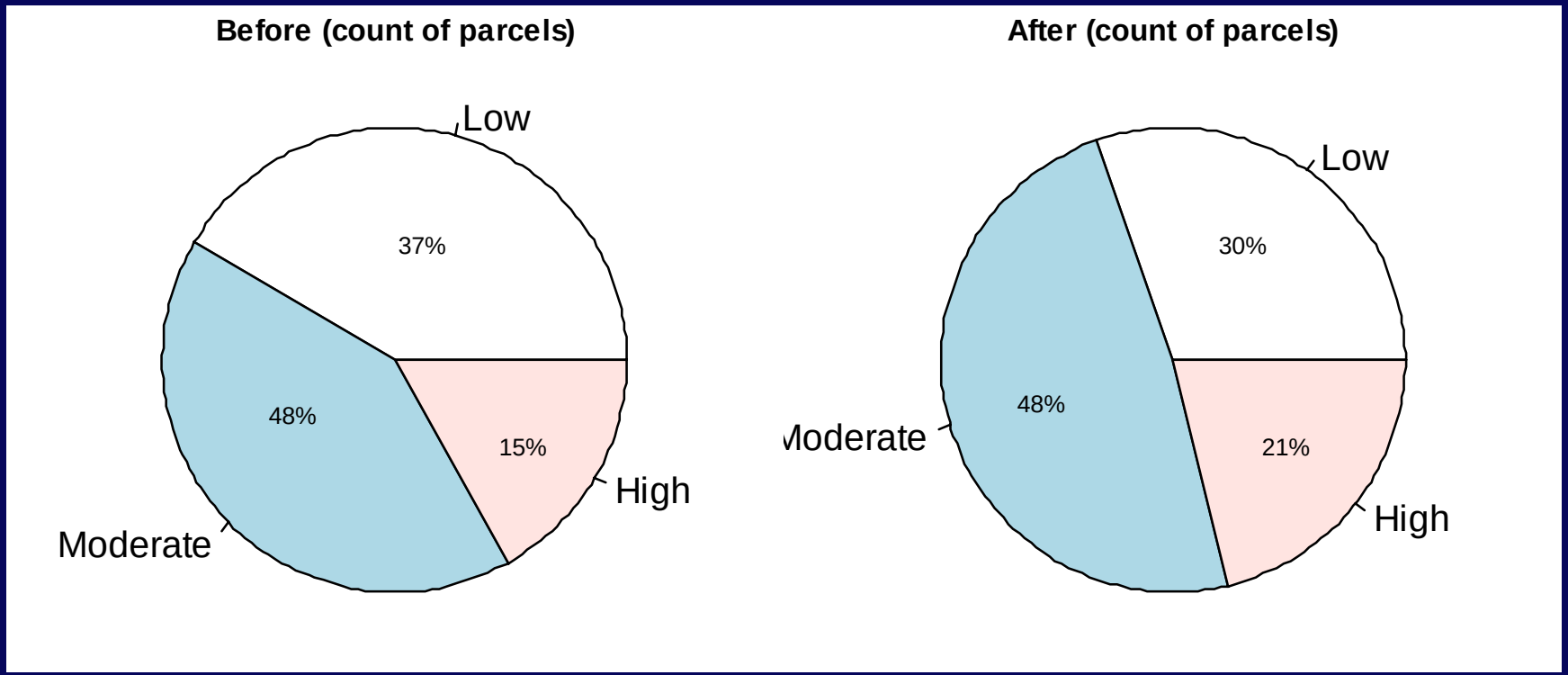


WBC Project GIS Intervention

Decrease size of closest office NC from 12 to 5 acres



Decrease Closest Office NC Size from 12 to 5 Acres



The Big Picture

- Using GIS we can estimate the effects of different intervention strategies on walkability.

Conclusion

- Tax-lot-level detailed data and development of new methods are needed for precise spatial-epidemiologic modeling.
- Use of geospatial analysis tools enhances the ability to understand the relationship between the built environment and health-related behaviors.
- GIS provides a mix of quantitative analysis and output with telling visualizations